

TRANSPORTATION RESEARCH DIGEST

SEPTEMBER 2008

ARIZONA TRANSPORTATION INSTITUTE

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TO: TRANSPORTATION PROFESSIONALS, MANAGERS, & POLICY MAKERS

FROM: ARIZONA TRANSPORTATION INSTITUTE

The volume of information on transportation issues, policies, technologies, and related topics is huge. Not even the most well-read professional can keep up with everything that might be useful to know. The *Transportation Research Digest* series is designed to expedite the transmission of information by condensing and summarizing significant documents. Busy professionals or managers may quickly obtain the gist of new developments and determine whether they need to see the full document.

The *Transportation Research Digest* is not meant to present definitive resolutions of scientific or policy controversies, but contributions to the pursuit of knowledge and the debate of issues. The intent is to be comprehensive rather than conclusive on the multitude of issues and topics of concern to those working in the field of transportation. Readers are encouraged to obtain the original document summarized in the *Transportation Research Digest* and subject the content to their own judgment.

Transportation professionals who would like to recommend documents to be summarized or submit summaries to be considered for inclusion in this publication are invited to do so. To recommend a document please send a copy (or information indicating how a copy can be obtained) of the research report to be summarized. To be considered, the report must meet the following requirements: (1) it is transportation related, (2) it is no more than two years old, (3) there is enough information in the report to warrant a two page summary. To write a summary, insure that the document being summarized meets the above requirements. The summary should be submitted in an electronic format. This summary should be in the 500 to 800 word range and may include tables and/or simple graphics—all of which must fit within the *Transportation Research Digest's* two-page format. Submissions are subject to editing for clarity and length. We do not guarantee that all submissions will be published.

If you would like to obtain the full report upon which a *Transportation Research Digest* summary is based you have several options. Check your local university library. You may want to contact the publisher using the contact information appearing in the *Transportation Research Digest*. Some of the documents are free for the asking. Others can be purchased.

There is a database listing of all the previously published *Transportation Research Digests* that we have on file (back to 1984). Copies of the list or of portions of the list selected by topic or mode can be provided on request. You may also access the database via the internet at

Transportation Research Digests from December 1995 to November 2003 are available on request.

A “Topic” code in the Table of Contents will help readers more quickly identify items of interest. The topic codes are explained in the table below.

<u>Code</u>	<u>Topic</u>	<u>Code</u>	<u>Topic</u>
ADM	Administration	PLAN	Planning
AIRP	Airports	PRIV	Privatization
AVIA	Aviation	RAIL	Railroads
BIKE	Bicycles	RDSO	Roadside
CON	Construction	ROW	Right-of-Way
ECON	Economics	SAFE	Safety
ENV	Environment	STR	Structures
FIN	Finance	TECH	Technology
INOV	Innovations	TOLL	Toll Roads
MAIN	Maintenance	TRAN	Transit
MISC	Miscellaneous	TRF	Traffic
MVD	Motor Vehicle Dept	TRK	Trucking
PAVE	Pavement	VEH	Vehicles

Requests or inquiries may be made via e-mail (jsemmens@cox.net).

Thank you.

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Counting Aircraft Operations at Non-Towered Airports, ACRP Synthesis 4 by Maria J. Muia Aerofinity, Inc. Indianapolis, Indiana (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; <http://gulliver.trb.org/bookstore>) (2007)

Highlights

- The most common method used is also the most inaccurate: simply asking the airport manager or other related airport personnel what they believe the airport's annual aircraft operations are.
- The most accurate and cost-effective way to estimate aircraft operations is to sample traffic for each of the four seasons and extrapolate an annual estimate.

This synthesis report has documented practices that are in use by some state aviation agencies, airports, and metropolitan planning organizations to count and estimate airport operations at non-towered airports. This study revealed that the following methods are being used across the United States and that these methods vary in accuracy:

- Count traffic year-round,
- Sample traffic and extrapolate annual operations,
- Multiply a predetermined number of operations per based aircraft by the total aircraft based at the airport,
- Perform regression analysis, and
- Ask the airport manager or personnel associated with the airport.

The most common method used by the respondents to this study's survey questionnaire is also the most inaccurate of the methods currently in use; simply asking the airport manager or other related airport personnel what they believe the airport's annual aircraft operations are. The Texas Department of

Transportation's 1994 *Aircraft Activity Counter Report* found that an airport's operations can be as much as doubled when estimated by the airport manager, as opposed to using the sampling traffic with an acoustical counter and extrapolating the sample into an annual estimate. Currently, the most accurate method is to deploy an aircraft traffic counter at an airport year-round, which in theory counts all the traffic at the airport. Seven respondents did this, four of which were airports.

It is believed that the next most accurate method to count and estimate operations is to sample traffic with some type of aircraft counter for two weeks in each of the four seasons and to expand that sample into an annual count. One study, when this method was used with the tape recorder acoustical counter, produced results with 9% to 21 % margins of error. However, only 6 of the remaining 12 respondents that sampled traffic actually did so for two weeks in each of the four seasons. The other six did not sample in all four seasons, making their results less accurate than those that sampled during all seasons or year-round. Determination of accuracy assumes that the technique used to extrapolate from sample to annual operations is appropriate in characterizing the airport's operating environment.

There are currently six different methods being used to sample aircraft traffic:

- Acoustical,
- Airport guest logs,
- Fuel sales,
- Pneumatic,

- Video image detection, and
- Visual.

The use of airport guest logs and fuel sales, although helpful, will not track all traffic during the sample period because not all pilots sign into a guest log and not all aircraft purchase fuel with each flight. Additionally, neither of these methods will account for touch-and-go operations. Of the equipment currently being used to sample traffic, the acoustical (including the sound-level meter and computerized acoustical) and video image detection systems offer acceptable levels of accuracy in detecting aircraft; both are estimated by their manufacturers to be in the 99% range. The acoustical systems are generally less expensive than the video systems, whereas the video systems offer more information, such as aircraft tail numbers. Visual sampling of traffic by a human observer is very accurate, but also very costly and time-consuming.

The most accurate and cost-effective way to estimate aircraft operations at a non-towered airport is to sample traffic for two weeks for each of the four seasons and extrapolate that sample into an annual estimate. This can be considered most preferable if year-round counts are not feasible, providing that a valid extrapolation is used to expand from seasonal counts to annual operations. The acoustical counter provides a cost-effective,

efficient, and accurate way to collect the sample, whereas the video image detection system, although more costly, adds additional information that may be useful to the airport. Pneumatic counters and inductance loop counters have serious limitations and would only be useful at airports that have a most simple configuration such as one runway and one entry taxiway, and are not recommended for such activities. Airport guest logs and fuel sales are not recommended as a way to count traffic.

The information received by the states, airports, and metropolitan planning organizations from their aircraft traffic counting programs is being used for a variety of purposes, including justification for airport improvement projects, justification for air traffic control towers, airport environmental documentation, forecasting, economic impact statements, performance measures, FAA Airport Master Record Form 5010 reporting, system planning, justification for navigational aids, and airport planning studies. Because the most common method for estimating aircraft operations (asking the airport manager or other airport personnel) may not be accurate, the information being used for these purposes may also be assumed not to be accurate. Additionally, because the methods being used to count and estimate aircraft operations at non-towered airports vary in accuracy, the results are not comparable among the airports.

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Field Evaluations and Guidelines for Rubblization in Texas by Stephen Sebesta and Tom Scullion, Texas Transportation Institute, Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office P.O. Box 5080, Austin, Texas 78763-5080; 979.845.1734; <http://tti.tamu.edu>) (Dec 2007)

Highlights

- Experience in this project with the MHB and RMI machines show that both devices can acceptably rubblize the concrete pavement.

This project evaluated several jointed-concrete pavement (JCP) projects for their suitability for rehabilitation by rubblization. A framework for analyzing a project's suitability using visual observation, ground penetrating radar (GPR), falling weight deflectometer (FWD), and dynamic cone penetrometer (DCP) assists in making an informed decision regarding rehab options. If rubblization is feasible, either one of the rubblizers should perform acceptably. However, extra care to employ proof rolling should be used when using the MHB for rubblization. If rubblization is not feasible, options such as a flexible base overlay or an overlay using crack and rut resistant mixes exist.

Conclusions Regarding MHB and RMI

Experience in this project with the MHB and RMI machines show that both devices can acceptably rubblize the concrete pavement. However, the Texas experience indicates the distinction between machines is unnecessary in the rubblization selection chart. Therefore, the researchers propose the chart shown previously in Figure 8.1. Additionally, while proof rolling is recommended prior to overlay regardless of which machine is used for rubblization, proof rolling especially is crucial when the MHB rubblizes the concrete. This is

because the wheel loads of the MHB stay on the unbroken concrete during operation. In contrast, the RMI traverses the rubblized section many times to complete one lane width; therefore, to an extent, the RMI machine serves as its own proof roller. As a minimum use a medium pneumatic roller with a ground contact pressure of at least 85 psi for proof rolling.

The break patterns produced by the two machines differ. The MHB produces larger particle sizes deeper in the concrete layer and flat, elongated particles at the top. These top particles are then broken down with the special Z-grid roller. In contrast the RMI process appears to produce a relatively uniform break pattern through the depth profile of the concrete layer. Figure 9.1 shows cross sections of the rubblized layer produced by each machine.

Recommendation for Pavement Thickness Design

To perform a mechanistic-based pavement design, the modulus value of the rubblized layer is needed. Prior literature and projects in Texas both indicate the JCP modulus after rubblization averages approximately 5% of the concrete modulus prior to rubblization. Therefore, project designers should use 5% of the backcalculated pre-rubblization concrete modulus to estimate the rubblized layer modulus for use in the pavement design. The rubblized layer may be incorporated into a new flexible or rigid pavement facility.

If a rigid (concrete) pavement overlay is to be placed over the rubblized layer, at least 4 inches of asphalt concrete pavement or asphalt stabilized base will need to be placed on top of the rubblized layer before the rigid overlay is placed. The thickness of the rigid pavement overlay is calculated using the new rigid pavement thickness design procedure in the 1993 AASHTO *Guide for Design of Pavement Structures*. Chapter 8 of the TxDOT Pavement Design Manual (revised October 2006) describes the procedure and inputs that TxDOT designers use for new rigid pavement thickness design. This manual can be downloaded at: <ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/pdm.pdf>.

Recommendations for HMA Overlay Mix Design

When rubblization is not an option, major advances in crack- and rut-resistant

HMA overlay design exist. The mixes should meet the Hamburg test requirement set forth by TxDOT 2004 Standard Specifications Item 341 and pass the overlay test requirements shown in Table 9.1 below. A good option is to use a 1 inch level up of a crack-attenuating mix (CAM) followed by a conventional surface mix. TxDOT Text Method Tex-242-F describes the Hamburg test, and Test Method Tex-248-F describes the overlay test.

Table 9.1. Cracking Requirements for Overlay Mixes.	
Mix Type	Minimum Number of Cycles to Failure
Type C, D	300
RBL or CAM	750

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17th Annual Report on the Performance of State Highway Systems (1984–2006) by David T. Hartgen and Ravi K. Karanam (Reason Foundation, 3415 S. Sepulveda Blvd., Suite 400, Los Angeles, CA 90034; 310/391-2245; <http://www.reason.org/ps369.pdf>) (Jul 2008)

Highlights

- The study calculates the effectiveness and performance of each state in 12 different categories, including traffic fatalities, congestion, pavement condition, bridge condition, highway maintenance costs, and administrative costs.

North Dakota's state-owned highway system is the nation's most cost-effective, an honor the state has held since 2001. North Dakota finished first, or tied for first, in five of the report's 12 categories, including rural interstate condition. Montana jumped from 5th to 2nd in the overall performance and cost-effectiveness rankings. New Mexico continues to show marked improvement. The state ranked 27th in 2000, and was up to 3rd overall in 2006. Wyoming moves up from 7th in 2005 to 4th overall. Kansas rounds out the top five.

New Jersey, which has ranked last every year since 2000, continues to be the nation's least cost-effective and worst-performing road system. Despite having the nation's 4th smallest state-owned highway system, New Jersey finished dead last in five of the study's 12 categories. Several of the least populous states performed very poorly, and make up the rest of the bottom five: Alaska (49th), Rhode Island (48th), Hawaii (47th), and New Hampshire (46th).

Texas, home to the nation's largest state-controlled highway system, ranked 12th overall in performance and cost-effectiveness. South Carolina, owner of the country's 5th largest system, ranks 6th overall. Georgia,

Ohio, Missouri and Virginia are some of the other top-performing large states.

As traffic jams in large cities escalate and spread to smaller areas, 35 states are now reporting that at least 40% of their urban interstate highways are congested, up from 31 states the previous year, according to an annual study of the nation's highways. With urban congestion even hitting South Dakota, the list of states without any clogged interstates is down to just three: Montana, North Dakota, and Wyoming.

Drivers in California, Minnesota, and North Carolina are stuck in the nation's worst traffic - over 70% of urban interstate highways in those states qualified as congested. California earned the dubious honor of "most congested" state - 83% of its interstates are congested, according to the 17th annual highway study by the Reason Foundation, a nonprofit think tank. Eighteen states now report that at least half of their urban interstate highways are congested.

Overall, 50.7% of the nation's urban interstate highways were congested in 2006, a slight 1% improvement from 2005, when 51.8% were jammed. The statistical improvement is due, at least partly, to many states increasing the declared capacities of their highways.

Deficient bridges were thrust into the spotlight in 2007 because of the tragic Minneapolis bridge collapse. Minnesota actually ranks 5th best in the nation, with 13% of its bridges deficient. Of the nearly 600,000 highway bridges in the country, 24.1% were

reported deficient and/or functionally obsolete in 2006, a minor improvement from 2005 when 25.5 were deemed deficient. At the current rate of repair it will take 62 years for today's deficient bridges to be brought up to date.

In Rhode Island a stunning 53% of state's bridges are deficient or obsolete. New Yorkers (38% deficient and obsolete) and Pennsylvanians (39%) won't feel much better

about the condition of their bridges. Nevada has the lowest percentage of deficient bridges in the country, 3.9%.

For the third consecutive year, Massachusetts had the safest highways (0.785 fatalities per 100 million vehicle miles traveled), while Montana's were the deadliest for the second straight year (2.364 fatalities per 100 million vehicle miles traveled).

Statistic	2004	2005	2006	% Change, 05-06
Mileage under State Control	810,707	812,871	814,770	0.23
Total Revenues, All Sources, \$B	\$90.68	\$102.71	\$104.73	1.96
Total Expenditures, \$B	\$87.69	\$98.91	\$99.61	0.7
Expenditures, Capital/Bridges, \$B	\$47.74	\$50.31	\$54.66	8.64
Expenditures, Maintenance, \$B	\$14.29	\$15.94	\$ 17 .07	7.09
Expenditures, Administration, \$B Highway	\$6.32	\$6.36	7.02	10.38
Construction Price Index Rural Interstate	154.4	175.4	185.1	5.5
Percent Poor Condition Urban Interstate	2.02	1.72	1.98	15.1
Percent Poor Condition Rural Primary	7.13	5.97	5.15	-13.7
Percent Poor Condition Urban Interstate	0.94	0.85	0.76	-10.6
Percent Congested Bridges,	51.6	51.85	50.72	-2.22
Percent Deficient	25.03	24.53	24.13	-1.63
Fatality Rate per 100 Mil Miles Driven	1.44	1.453	1.421	-2.2
Rural Primary, Percent Narrow Lanes	10.72	10.7	10.6	-0.93

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Exploring the Methods to Increase Seat Belt Usage in Kansas by Sunanda Dissanayake and Abhishek S. Parikh, Department of Civil Engineering, Kansas State University, 2136 Fiedler Hall, Manhattan, Kansas 66506 (Kansas Department of Transportation, Bureau of Materials and Research, 700 SW Harrison Street, Topeka, Kansas 66603-3754) (Sep 2007)

Highlights

- ❑ Converting from secondary to primary law could be expected increase seat belt usage rate by approximately 11%.
- ❑ Increasing the penalty by ten dollars could be expected to increase seat belt use by approximately 4.8%.

Even though seat belt usage has increased steadily over the last decade, still it has not reached a level, where maximum benefits can be obtained. The challenge now is to increase restraint usage among groups and individuals who have not yet accepted the educational or enforcement messages related to the safety benefits of wearing the seat belt. This study focused mainly on identifying these critical groups, as well as other factors like locations, policies and regulations etc that influence seat belt usage rates and the associated safety outcomes.

In order to achieve these objectives, several statistical models were developed where one model was for identifying the factors affecting the state seat belt usage rate. Two critical factors, African-American population and rural highway mileage were identified as inversely related to seat belt usage rates, the higher the African American population or rural highway mileage is, the lower the average usage rate in a state is. Along with this, six factors were identified as positively affecting seat belt usage rates. Among these, type of seat belt law is the most significant factor that could increase the average usage rate in a state. Based

on the estimates of this study, converting from secondary to primary law could be expected increase seat belt usage rate by approximately 11% in Kansas. This estimated increase was found to be consistent with examples of states like Michigan, New Jersey, Oklahoma, Washington, Alabama and Washington D.C, which showed an increase in seat belt usage rate by approximately 9-14% by converting from secondary to primary enforcement.

Another significant factor that would be helpful in increasing seat belt use is increasing the penalty for violating the seat belt law. It was found that increasing the penalty by ten dollars could be expected to increase seat belt use by approximately 4.8%. Similarly, factors like fuel tax, crime rate, median income and miles of interstate road were found to positively influence seat belt usage rates.

The effect of seat belt law and other associated factors on occupant fatalities was also studied in this research. Statistical model on unrestrained occupant fatality percentage identified four factors that are capable of reducing the amount of unrestrained occupant fatalities. Among them: primary seat belt law was the most significant factor, where it was estimated that converting to primary law would reduce fatalities by approximately 10%. Other factors identified as reducing fatalities are median household income level, miles of interstate road and unemployment rate. The results also suggested that higher percentage of African-American and Hispanic population, young drivers and alcohol involvement among

drivers involved in fatal crashes leads to higher percentage of unrestrained occupant fatalities. Accordingly, they could be identified as critical areas that need focused attention.

Similarly, another statistical model developed in this study, fatality rate model, also identified seat belt law as the most critical factor in decreasing fatality rate in a given state. Based on the estimates of this model, converting to primary enforcement could have saved 48 to 104 lives in Kansas in year 2002 alone. Other factors that are identified as capable of reducing fatality rate were increased median household income, fuel tax and travel time. The factors that were found to increase fatality rate were African American and Hispanic population, maximum speed limit law, and rural population.

Road user surveys indicated that in Kansas awareness about seat belt related law is lower among lower income groups, younger drivers, Hispanics and African Americans. The majority of Kansans seems to not be familiar with the specifics of the seat belt law. Results also indicate that seat belt usage is lower among males, younger drivers, lower income groups, pick-up truck drivers, and Hispanics. Some other factors affecting seat belt usage among the survey sample were driving short distance, driving at night, driving under bad weather, etc.

From the results obtained by statistical models and surveys these factors were identified to affect seat belt use and occupant fatalities:

Demographic and Socio-economic Variables -- Higher median household income

was found to increase seat belt usage rate and decrease both unrestrained occupant fatalities and fatality rate whereas higher percentages of African American and Hispanic population, rural population, and young drivers were found to increase either unrestrained occupant fatality percentage or fatality rate. Additionally, crime rate increases seat belt use and percentage of unemployed labor force decreases unrestrained occupant fatalities, most likely due to lesser travel by unemployed individuals.

Policy and/or Regulations -- Primary seat belt law was the most significant variable under this category to increase seat belt use and decreasing both unrestrained occupant fatalities and fatality rate. Fuel tax and penalty for not wearing seat belt were also found to increase seat belt usage rates while fuel tax also decreased fatality rate. Additionally maximum speed limit law affects fatality rate.

Roadway and Traffic Characteristics -- Higher interstate road mileage was found to increase seat belt usage rate in a state and decrease unrestrained occupant fatalities. Rural highway mileage was found to decrease seat belt usage rates and travel time for commuting to work decreased unrestrained occupant fatalities, indicating higher seat belt use for longer commute or travel. It should be noted that these findings represent the characteristics of road users rather than direct effect of these variables. For example since people are more likely to buckle up on interstate roads, increased interstate mileage also increases the average usage rate.

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Guidebook for Mitigating Fixed-Route Bus-and-Pedestrian Collisions, TCRP Report 125 by Kelley Klaver Pecheux, Jocelyn Bauer, Sheryl Miller, Jennifer Rephlo, Harry Saporta, Samantha Erickson, Sue Knapp, Jason Quan (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; <http://gulliver.trb.org/bookstore>) (2008)

Highlights

- This guidebook provides transit agencies with an array of strategies from which to choose for mitigating the frequency and severity of bus-and-pedestrian collisions.

The goal of the project was to gather quantitative and qualitative data to determine the frequency of bus- and-pedestrian collisions, to understand factors that contribute to their occurrence, and to identify implemented and potential strategies to mitigate their occurrence and severity. This *Guidebook* will assist transit agencies and community members in understanding the problem of bus-and-pedestrian collisions and in determining preventative or remedial strategies for reducing the frequency and severity of these types of collisions.

During the 18-month investigation, a team composed of transportation researchers gathered information using a variety of sources, including literature and previous research, incident reports, focus group meetings, and one-on-one interviews. The research team focused on obtaining information and data from a sample that is geographically diverse; one that includes the needs and perspectives of small, medium, and large transit agencies; and one that includes input from a large array of stakeholders. In addition to 22 pedestrians and 26 bus operators, 60 agencies and organizations provided input that went into the development of this *Guidebook*.

This *Guidebook* is organized into four parts and presents a number of strategies to meet the needs of different users. Part 1 discusses how to mitigate the four most common collision types and circumstances as identified during the investigation, each of which is described and illustrated.

Part 2 presents a variety of strategies, including operator training and outreach, safety checks, defensive driving techniques and policies, public outreach and education, traffic engineering and roadway design, bus mirror configuration and placement, bus design/modification, bus stop location planning and bus stop design, and bus stop lighting and illumination. Detailed information for more than 80 applications of the strategies is presented, as well as information on many more suggested applications of the strategies.

Part 3 contains 14 case studies, which provide in-depth examples for the best documented applications of the strategies. The case studies include single-agency case studies, which detail how individual agencies have addressed pedestrian safety issues, and multi-agency case studies, which compare the same applications implemented across multiple agencies. The case studies include detailed information about what is known about the bus-and-pedestrian collision problem, the implementation of one or more mitigating strategies, the goals and costs of implementation, and the successful and problematic elements of strategy implementation.

Finally, Part 4 presents a discussion of important considerations for improving pedestrian safety around transit buses. This section includes a description of contributing factors that are not necessarily directly linked to one of the four primary types of bus- and-pedestrian collisions described in the Guidebook, but that were identified by transit agencies and other stakeholders as playing an important role in the occurrence of these collisions. This section also discusses how to

approach strategy implementation and specifically how to combine two or more strategies to add to the potential for success in reducing bus-and-pedestrian collisions and improving overall safety.

This guidebook provides transit agencies and stakeholders with an array of strategies from which to choose for mitigating the frequency and severity of bus-and-pedestrian collisions, as well as approaches for doing so.

TRANSPORTATION RESEARCH DIGEST

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SEPTEMBER 2008

Pedestrian and Bicyclist Intersection Safety Indices: User Guide by Daniel L. Carter, William W. Hunter, Charles, V. Zegeer, and J. Richard Stewart, Pedestrian and Bicycle Information Center, Highway Safety Research Center, University of North Carolina, 730 Martin Luther King Jr. Boulevard, CB #3430, Chapel Hill, NC 27599 (Turner-Fairbank Highway Research Center, Federal Highway Administration, 6300 Georgetown Pike, McLean, VA 22101; (202) 493-3260; <http://www.tfhrcc.gov>) (Apr 2007)

Highlights

- This method enables the practitioner to prioritize and proactively address sites that are the most likely to be a safety concern for pedestrians or bicyclists.
- The method uses observable and easy-to-gather data.

The Pedestrian and Bicycle Intersection Safety Indices (Ped ISI and Bike ISI) are a set of models that enable users to identify intersection crossings and intersection approach legs that should be the greatest priority for undergoing pedestrian and bicycle safety improvements. Using observable characteristics of an intersection crossing or approach leg, the tool produces a safety index score, with higher scores indicating a greater priority for an in-depth safety assessment. Each leg of an intersection may have different characteristics affecting pedestrian or bicyclist safety; therefore the tools are intended to provide an evaluation of the safety of an individual crossing (Ped ISI) or approach leg (Bike ISI) rather than evaluating the intersection as a whole. A practitioner can use the tool to develop a prioritization scheme for a group of pedestrian crossings or bicyclist approaches. This method enables the practitioner to prioritize and proactively address sites that are the most likely to be a safety concern for pedestrians or bicyclists.

National crash statistics for 2004 show that 4,641 pedestrians and 725 pedalcyclists were killed in crashes, accounting for approximately 13% of all traffic fatalities in the United States. Most of these crashes occur at intersections. Many States and municipalities have pedestrian and bicycle safety programs to identify and address high crash locations. Although these safety programs can treat pedestrian or bicyclist hazards as they are identified, it would be preferable to use a proactive method of prioritizing which intersections should be examined first to ensure that potentially risky locations are addressed before they become crash problems.

Ped ISI and Bike ISI pro actively prioritize pedestrian crossings and bicyclist approaches with respect to safety. They also provide forward-looking State and local planning agencies with a safety rating tool for proposed intersections. Each tool uses observable and easy-to-gather data.

Ped ISI and Bike ISI were developed at urban and suburban intersections with the following characteristics:

- Three-leg and four-leg intersections.
- Signalized, two-way stop, and four-way stop.
- Traffic volumes from 600 to 50,000 vehicles per day.
- One-way and two-way roads.
- One to four through lanes.

- Speed limits from 15 to 45 miles per hour.

Ped ISI and Bike ISI are used most appropriately at intersections that meet the above ranges. Safety index values produced for intersections with characteristics outside these ranges should be used only with the understanding that the models were not developed using intersections of that type.

Steps for Using the Ped ISI & Bike ISI

1. Identify pedestrian crossings (Ped ISI) or intersection approaches (Bike ISI) to evaluate. It is not necessary to evaluate all intersections in a given locality at once, especially where there are a large number of sites. Here are some useful tips for considering how to begin selecting sites:

- Are there sites in the planning stage that could be modified in the design phase to avoid potential problems?
- Is there an area where there may be moderate to high pedestrian and/or bicyclist activity, such as in a central business district or near a popular pedestrian or bicyclist attractor?
- Are there sites that have already been identified in the community (including residents or other users) as possible problems?
- Are there sites where a crash has occurred? Typically these tend to

naturally receive focused attention, but it may also prove useful to develop a safety index score to provide perspective, or to help identify what factor(s) may be affecting safety.

2. Gather data on geometric and operational characteristics of the selected sites, either through electronic databases or brief field visits. If the sites are in the planning stages, determine what characteristics the sites are expected to have.

3. Use Ped ISI and Bike ISI to produce index values for each site. Each site will receive a safety index value between 1 (safest) and 6 (least safe).

4. Sort sites according to index values. Sites with the highest index values generally have the highest priority for further in-depth evaluation of pedestrian and/or bicycle safety. However, the existence of a high Ped ISI or Bike ISI value does not mean that a crosswalk or intersection approach is necessarily "hazardous." There are many characteristics and behaviors at an intersection that will result in a pedestrian or bike crash, and no method can include all of these factors. Knowledge of the area should also be used in the prioritization of sites. The Ped ISI/Bike ISI method merely provides a way to prioritize locations to identify those which may warrant more in-depth study.

TRANSPORTATION RESEARCH DIGEST

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Relationship of Lane Width to Safety on Urban and Suburban Arterials by Ingrid B. Potts, Douglas W. Harwood, and Karen R. Richard in *Transportation Research Record 2023* (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; <http://gulliver.trb.org/bookstore>) (2007)

Highlights

- It was concluded from this research that there was no indication of an increase in crash frequencies as lane width decreased for arterial roadway segments or arterial intersection approaches.

The conventional wisdom of most highway engineers is that use of narrower lanes in the design of a roadway will result in more crashes if other design characteristics of the roadway remain unchanged. This has been demonstrated for lane widths on rural two-lane highways, but there is no definitive research on the safety effect of lane widths for urban and suburban arterials. If narrower lanes can be used on urban and suburban arterials without affecting safety negatively, there may be many other benefits to highway agencies and highway users. The use of narrower lanes may have advantages in some situations on arterials by reducing pedestrian crossing distances or providing space for additional through lanes, auxiliary lanes, bicycle lanes, buffer areas between travel lanes and sidewalks, and placement of roadside hardware. Concerns have been raised that the use of narrower lanes could increase crash frequencies, but there are no definitive studies that address the relationship between lane width and safety for urban and suburban arterials.

The results of past studies to determine the traffic safety effects of lane width are varied. Despite the extensive research that has been conducted on this issue, it is difficult to

draw any definite conclusions about the relationship. For on-road crashes, lane width was found to be associated with property-damage-only (PDO) crashes but not injury crashes. For the PDO model, wider lanes were associated with higher crash frequencies (not lower ones). However, the relationship is weak.

Research on the design attributes and safety of Oregon state highways found no relationship between lane width and crash frequency for urban nonfreeways.

Negative binomial regression models found significant relationships between lane width and crashes for undivided highways. Increasing lane widths up to 3.6 m (12 ft) and 4.0 m (13 ft) would be expected to decrease crash rates for urban two-lane and four-lane undivided roadways, respectively.

While reducing crossing distance for pedestrians at intersections is considered desirable, no studies have documented the quantitative effect of lane width on pedestrian or bicycle safety evaluation of lane widths for arterial roadway segments found no indication, except in limited cases, that narrower lanes increased crash frequencies. The lane width effects in the analyses conducted were generally either not statistically significant or indicated that narrower lanes were associated with lower rather than higher crash frequencies. There were limited exceptions to this general finding. It was found that crash frequency in one state was higher for 3.0 m (10 ft) lanes than for 3.3 and 3.6 m (11 and 12 ft) lanes on four-lane undivided arterials and was higher in the

other state for 2.7 m (9 ft) lanes than for 3.0 m (10 ft) lanes on four-lane divided arterials. However, neither of these statistically significant effects observed in one state was statistically significant in the other state.

Similarly, a safety evaluation of lane widths for arterial intersection approaches found no indication, except in limited cases, that the use of narrower lanes increased crash frequencies. The lane width effects in the analyses conducted were generally not statistically significant or they were inconsistent. With only one limited exception, there was no indication that the use of lanes narrower than 3.6 m (12 ft) on intersection approaches led to increases in crash frequency. The data for one state showed higher crash frequencies for approaches to four-leg stop-controlled intersections for approaches with 3.0 m (10 ft) lanes than for approaches with 3.6 m (12 ft) lanes; however, just the opposite was found in data from the other state.

It was concluded from this research that there was no indication of an increase in crash frequencies as lane width decreased for arterial roadway segments or arterial intersection approaches.

These findings suggest that the *AASHTO Green Book* is correct in providing substantial flexibility for use of lane widths narrower than 3.6 m (12 ft) on urban and suburban arterials. Use of narrower lanes in appropriate locations can provide other benefits

to users and the surrounding community, including shorter pedestrian crossing distances and space for additional through lanes, auxiliary and turning lanes, bicycle lanes, buffer areas between travel lanes and sidewalks, and placement of roadside hardware. Interpretation of design policies as rigidly requiring the use of 3.6-m (12-ft) lanes on urban and suburban arterials may miss the opportunity for these other benefits without any documentable gain in safety.

The research found three situations in which the observed lane width effect was inconsistent--showing increasing crash frequency with decreasing lane width in one state and the opposite effect in another state. These three situations are the following:

- Lane widths of 3.0 m (10 ft) or less on four-lane undivided arterials,
- Lane widths of 2.7 m (9 ft) or less on four-lane divided arterials, and
- Lane widths of 3.0 m (10 ft) or less on approaches to four-leg stop-controlled arterial intersections.

Because of these inconsistent findings, it should not be inferred that the use of narrower lanes must be avoided in these situations. Rather, it is recommended that narrower lanes be used cautiously in these situations unless local experience indicates otherwise.

TRANSPORTATION RESEARCH DIGEST

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Bridge Deck Service Life Prediction and Costs by Gregory Williamson, Richard E. Weyers, Michael C. Brown, and Michael M. Sprinkel, Virginia Transportation Research Council, 530 Edgemont Road, Charlottesville, VA 22903 (Virginia Department of Transportation, 1401 E. Broad Street, Richmond, VA 23219) (Dec 2007)

Highlights

- Polymer overlays are the most economical option in nearly all cases.
- Concrete overlays are more cost effective only if the average daily traffic (ADT) is expected to be very high.

The service life of Virginia concrete bridge decks is generally controlled by chloride induced corrosion of the reinforcing steel as a result of the application of winter maintenance deicing salts. A chloride corrosion model accounting for the variable input parameters using Monte Carlo resampling was developed. The model was validated using condition surveys from 10 Virginia Bridge decks built with bare steel. The influence of changes in construction specifications of $w/c = 0.47$ and 0.45 and $w/cm = 0.45$ and cover depth increase from 2 to 2.75 inches were determined. The 0.45 w/c bridge decks reflected little to no damage due to their young age relative to the older 0.47 w/c bridge decks. The C_o values demonstrate the similarities between the three deck sets. The average cover depths are generally higher for the 0.45 w/c bridge deck sets. This is due to the VDOT specification change of an increase in cover depth that coincided with the decrease in the w/c from 0.47 to 0.45 . In general, there was little difference between D_{ca} values normalized to age 35 years and the average calculated values for the age at sampling.

Histograms of the input data were developed for each of the three bridge deck sets

to investigate the distributions of the input parameters. The histograms indicate that C_o , and D_c may be reasonably described by the gamma distribution while cover depths follow a normal distribution which is in agreement with previous studies.

Life cycle cost (LCC) comparison tables were developed for decks where a maintenance strategy may be selected within the next 50 years in 10-year intervals. The tables are presented with and without traffic control costs and without user costs. Where bridge maintenance decisions are to be made in years other than those presented in the tables, the LCCs may be approximated by a linear interpolation between adjacent 10 year periods.

Using the cash flow diagram presented in the report, the engineer can investigate the effects of varying traffic volumes on the selection of the appropriate maintenance strategy. Polymer overlays are the most economical option in nearly all cases. Concrete overlays are more cost effective only if the average daily traffic (ADT) is expected to be very high and the required remaining service life falls within certain time frames.

Conclusions

The time to first repair and rehabilitation of bridge decks can be modeled using a probabilistic approach, which allows for the incorporation of variability related to chloride exposure conditions, bridge deck construction, and corrosion initiation.

Fick's second law of diffusion can be used to model the apparent diffusion rate of chlorides into a concrete bridge deck. Additionally, the effective diffusion rate at any point in time can be projected using available diffusion decay models.

The time required for corrosion to induce cracking in the cover concrete can be estimated using existing corrosion-cracking models. An estimated time to corrosion cracking of 6 years for bare steel reinforcement was determined for this study.

A reasonable estimate of the time required for corrosion deterioration to progress from a level of 2% to a level of 12% was determined from damage surveys conducted on actively corroding bridge decks. The corrosion propagation time for bare steel bridge decks is estimated to be 16 years.

The reduction of the w/c ratio from 0.47 to 0.45 appears to have a negligible effect on the diffusion properties of the sampled bridge deck concrete.

The addition of fly ash or slag to the sampled bridge deck concrete mixture appears to dramatically reduce the diffusion rate of chlorides into concrete and have equivalent long term corrosion protection effects.

The service lives of bridge decks constructed under current specifications (0.45 w/cm and 2 in cover depth) are expected to exceed a design life of 100 years regardless of reinforcement type.

Surface chloride concentrations, C_o , have been determined for the Commonwealth of Virginia and are only a function of the environmental exposure conditions not the type of concrete.

Apparent diffusions, D_{ca} , have been determined for the Commonwealth of Virginia for w/c = 0.47, w/c = 0.45 and w/cm = 0.45 bridge deck concrete and may be used in estimating the rate of corrosion damage to bridge decks within the Commonwealth of Virginia.

The rate of deterioration of populations of bridge decks built under different state wide specifications may be determined using the probability based chloride diffusion model, plus the time to cracking of 6 years, plus the propagation period of 16 years for 2% to 12% damage of the worst span lane.

The diffusion model plus the time to cracking and propagation periods may be used to predict the rate of corrosion damage for individual decks provided sufficient input data is provided. Model data requirements are provided in the recommendations section of the report.

Life Cycle Cost Analysis (LCCA) can be conducted to determine optimum maintenance strategies for individual bridge decks.

It is not appropriate to specify a single maintenance strategy for all bridge decks within a system, as the most economical alternative will be dependent upon individual structure parameters.

Long-term inflation rates associated with transportation-related construction appear to correspond with the inflation rate of the general economy.

A total maintenance cost approach to maintenance strategy selection generally results in the same conclusions as a LCCA approach.

TRANSPORTATION RESEARCH DIGEST

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Rotation Limits for Elastomeric Bearings, NCHRP Report 596 by John F. Stanton, Charles W. Roeder, Peter Mackenzie-Helnwein, Christopher White, Colin Kuester & Brianne Craig, Department of Civil & Environmental Engineering, University of Washington, Seattle, WA (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; <http://gulliver.trb.org/bookstore>) (2007)

Highlights

- ❑ Cyclic loading was found to cause progressive debonding of the elastomer from the internal steel shims.
- ❑ Failure was never sudden. Thus, there is a need for judgment in establishing a level of damage that constitutes failure.
- ❑ The results of the tests and analyses were combined to develop design procedures suitable for adoption in the *AASHTO LRFD Bridge Design Specifications*.

The response of elastomeric bridge bearings to imposed rotations was studied using testing and analysis. The program concentrated on steel-reinforced elastomeric bearings.

The demand on typical bearings was evaluated by analyzing a range of bridges and evaluating the amplitudes of the axial loads and rotations on the bearings that are likely to occur in practice. During this process, it was found that cyclic axial forces cause larger strains in the elastomer than do the cyclic rotations. However, resource limits in the program precluded cyclic axial testing, and the discovery was anyway made quite late in the program. Thus, in the development of design procedures, the effects of cyclic axial load were taken into account by analysis alone.

The capacity of the bearings to accommodate the loads and rotations without excessive damage was evaluated by a program of testing and analysis of the bearings themselves. The test program included material

tests, static and cyclic tests on full bearings, and diagnostic tests on full bearings to evaluate their instantaneous state of damage. In all, 78 bearings were tested. The bearings were purchased from the four largest manufacturers in the country.

Static and low-cycle repeated load tests were conducted under axial load with or without a fixed rotation. Stresses up to 12,000 psi were applied. Bearings with high shape factors (9 and 12) were able to carry the loads with no damage whatsoever, while bearings with lower shape factors suffered various levels of damage. The cyclic rotation tests were conducted in a specially constructed test machine that is capable of applying simultaneously constant axial load, constant shear displacement and cyclic rotation. Peak capacities are 800 kips axial load and +/-8% rotation. Cyclic loading was found to cause progressive damage, analogous to fatigue in metals. However, the damage was in the form of progressive debonding of the elastomer from the internal steel shims, so failure was never sudden. At the end of every cyclic test, the bearing could still easily carry the axial load, even though other properties had degraded. This finding creates the need for judgment in establishing a level of damage that constitutes failure.

Failure of a component is usually expressed in terms of critical stress or strain, and the same approach was used with the bearings studied here. However, measuring

local strains in rubber is difficult, so analysis was necessary to relate the internal stress and strain fields to the external loadings that caused them. Classical, closed-form analytical techniques for laminated incompressible materials were used for the purpose, and nonlinear Finite Element Analysis (NLFEA) was used to verify that the closed-form methods were sufficiently accurate to warrant their use in design procedures. Empirical fatigue models were also generated to predict the progress of damage under cyclic loading.

The results of the tests and analyses were combined to develop design procedures

suitable for adoption in the *AASHTO LRFD Bridge Design Specifications*. Major proposed changes from the present specifications include the removal of the absolute limit on compressive stress, so that the design of high shape factor bearings for high stresses will be possible, the removal of the previous "no-uplift" provisions, which were causing difficulties for designers, and a change in the testing requirements so that the second-level, more rigorous testing is required for large bearings rather than any bearing designed by the more comprehensive "Method B."

TRANSPORTATION RESEARCH DIGEST

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Drivers' Preferences for Traffic Information for Nonrecurrent Traffic Situations by Thijs J. Muizelaar and Bart van Arem in *Transportation Research Record 2018* (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; <http://gulliver.trb.org/bookstore>) (2007)

Highlights

- The top three preferences for traffic information content are:
 1. advice for the fastest route to the destination;
 2. location, length, cause, and expected duration of traffic jams on the complete network; and
 3. expected time of arrival with a margin of 5% for an advised route.

1. Determining traveler preferences for ATIS, including type of information;
2. Understanding and modeling route choice behavior;
3. Representing and modeling cognitive processes;
4. Assessing and evaluating the effects of ATIS; and
5. Conceptualizing dynamic models of the interaction between behavior and ATIS.

Modern western countries are increasingly experiencing problems with traffic and transport, such as congestion, accidents, and pollution. Intelligent transport systems (ITS) are expected to contribute to solving these problems. Advanced traveler information systems (ATIS) as part of ITS are one of the possible contributions that aim at informing travelers about the current and future state of transport systems, such as road traffic.

The main goal of providing traffic and travel information is a more efficient use of the road or transport network, as a result of travelers having better knowledge about available options. That, however, is the goal of transport network managers. Travelers want to have more efficient routes and less stress during their travel, which implies a different use of information. Besides reducing travel time and distance, minimizing delays and fuel use are also important to travelers. To be able to understand and predict the use of traffic and travel information, the following five areas need extensive research:

Conclusions

ATIS is a strongly developing field. The success of ATIS depends on whether drivers consider it useful. This paper addressed a specific issue that has received little attention so far, namely, the preferences of drivers for ATIS in nonrecurrent traffic situations, such as incidents, road work, and large events. The paper studied the traffic information content and characteristics of the traffic information. For this purpose an Internet survey was used. Results were analyzed with statistical tests and a multinomiallogit model.

The top three preferences for traffic information content are (a) advice for the fastest route to the destination; (b) location, length, cause, and expected duration of traffic jams on the complete network; and (c) expected time of arrival with a margin of 5% for an advised route. Choice of traffic information content also depends on certain personal characteristics. The most important characteristics influencing the preference for traffic information are use of the traffic

information during travel and driver type and age.

These findings imply that drivers have different needs for information in different situations. These needs depend on the type of nonrecurrence and the familiarity with the road network and the motive for car use. The findings also show that users that are more experienced with traffic information have needs that are different from users with less experience. This underpins the idea of a learning driver, in which the driver learns not only about the road network and traffic situation, but also about traffic information. The type of traveler was, as expected, also a significant explanatory variable for preferences, because it is a classification of travelers based on their outlook on mobility. It is therefore a substitute for a number of variables that might otherwise not have been found as explanatory.

Drivers' preferences for characteristics of traffic information were investigated with a multinomiallogit model. Results show that drivers have a large preference for the "no information" alternative against other information types in instances in which costs were involved; as expected, cost is valued negatively. Nevertheless, in several conditions

drivers appeared to be prepared to pay for traffic information. Delay in the broadcast of the traffic information was valued negatively, but compared with costs, this characteristic is less important. Increasing reliability was valued positively by drivers. Apart from these characteristics, there is no clear preference for one of the four information types (apart from no information). There is a slight indication that drivers prefer either advising information or personalized information. The last type, in particular, would indicate a system that can incorporate the driver's specific demands and experiences.

This study shows that providing general traffic information to all drivers in all conditions will be no guarantee of a successful deployment of ATIS. Drivers' preferences for information differ per situation and depend on personal characteristics. For ATIS to be successfully accepted, it should be made to adapt to traffic situations and to drivers. Finally, the preference for information also appears to depend on the drivers' level of experience with traffic information and the availability of a navigation system.

TRANSPORTATION RESEARCH DIGEST

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Georgia's Approach to Congestion with the Four T's: Tolling, Transit, Telework, and Technology by Rosa Rountree, et al. in *Transportation Research Board, 87th Annual Meeting, January 13-17, 2008, Washington, DC*. (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; <http://gulliver.trb.org/bookstore>).

Highlights

- A Commuter Credits program was conceived to address equity concerns for priced managed lanes while also attempting to motivate alternate commute choices.
- The goal of Commuter Credits is to provide a reward program that is highly acceptable and motivational to shift commutes to alternate travel times and/or travel modes.
- Traditional police enforcement will also be aided by deployment of technologies such as Mobile Enforcement Readers and mobile Automated License Plate Readers (ALPR).

Recognizing the severity of the Atlanta region's current traffic congestion and its likelihood to worsen as our population continues to grow, many of Georgia's agencies have collaborated to develop an application for an Urban Partnership Agreement with the U.S. Department of Transportation. The Atlanta region's proposed Urban Partnership project centers around priced managed lanes in one of the metro area's most congested corridors – the I-85 Northwest Expressway – augmented by options that align with the “Four Ts”: tolling/pricing the HOV lane, transit via coach buses for commuters from the northeast suburbs, teleworking via expanded employer outreach, and technology applications to support the integration of these new transportation options.

As a demonstration, Georgia's proposal will have broad application for other metropolitan regions across the country

considering its innovative aspects and incorporation of technologies across transportation modes. The proposed Commuter Credits program was conceived to both address equity concerns for priced managed lanes while also attempting to motivate alternate commute choices. For enforcement, deployment of an “invisible barrier” called Gantry Controlled Access will automate entry, exit, and lane enforcement of managed lanes that could potentially save hundreds of million of dollars and time on future projects.

Traditional police enforcement will also be aided by deployment of technologies such as Mobile Enforcement Readers and mobile Automated License Plate Readers (ALPR). Georgia's demonstration project will also be able to quantify successes and performance measures through Georgia Tech's unique instrumented vehicle fleet and the Commuter Credits program, allowing for direct cross modal trip comparisons.

Underpinning the Four Ts will be a new program called Commuter Credits. The primary purpose is to address equity concerns by providing opportunities for commuters to earn credits toward free passage, thus the priced managed lane is not limited to those who can pay. Credits can be earned by a commuter for choosing a mode or time of travel other than single-occupant vehicles during rush hour. Another intention of the Commuter Credits program is to effect mild reductions in highway congestion levels.

Rather than driving alone in their cars during the most congested hours, the Commuter Credits program would enable commuters to accumulate credits for using transit, driving during the “shoulder” hours of the peak periods, as well as telecommuting, vanpooling, or carpooling to get to work. Similar to airlines’ frequent flyer miles, Commuter Credits would be earned according to a prescribed schedule of alternate travel behavior and redeemed in an easy-to-understand format. Figure 2 depicts possible Commuter Credits accrual and reward schedules.

A worker’s accrual of Commuter Credits would be tracked using electronic collection transponders. And just like Georgia State Road and Tollway Authority’s (SRTA) Cruise Card program, the Commuter Credit program is an “opt-in” system – commuters only sign up to earn and redeem Credits if they choose to.

The goal of Commuter Credits is to supplement the HOV-to-HOT conversion by providing a reward program that is both highly acceptable to the general public and also appropriately motivational to shift commutes to alternate travel times and/or travel modes. The desired outcome is a reduction of highway traffic volumes during the most congested peak hour(s). Other core goals of Commuter Credits are maintaining air quality conformity and targeting socioeconomic equity.

The Commuter Credit concept has been met with a high level of acceptance when presented to transit operators, transportation planners, and travel demand managers in the Atlanta region. The key to acceptance is the ability of the Commuter Credit program to provide transportation choices to all commuters, regardless of their ability to pay the lane fee, while also rewarding alternate travel behavior and maintaining consideration for socioeconomic equity.